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RESEARCH ARTICLE

Occurrence of bovine cysticercosis in animals slaughtered in two facilities at Mato Grosso do Sul state, Brazil

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Abstract
Bovine cysticercosis results in economic losses to cattle raisers and slaughterhouses and poses health risks to the population. Cysticercosis is caused by *Taenia saginata*, whose life cycle involves the use of livestock and humans as hosts. The objective of this study was to obtain information on the occurrence of cysticercosis in 2 slaughterhouses in the southern region of the state of Mato Grosso do Sul, Brazil by consulting records on the origin of slaughtered animals and associated diseases, obtained through *post-mortem* inspection performed by the Brazilian Federal Service of Inspection (SIF) of the Ministry of Agriculture, Livestock and Supply (MAPA). The data were presented based on descriptive statistics, and all analyzes were performed in the statistical program "R". In slaughterhouse "A", the highest reported rate of cysticercosis was 2.40%, and the municipality with the highest number of cases was Amambaí. In slaughterhouse "B", the highest reported rate was 6.02%, and the municipality with the highest number of cases was Vincentina. For both slaughterhouses, the highest number of cysticercosis cases occurred in January. Together with other studies performed in the same Brazilian state, these data indicate that bovine cysticercosis cases are increased in the state of Mato Grosso do Sul, demanding additional effective measures for its control.

Keywords Cysticercosis · Slaughterhouse · Inspection · Sanitary conditions

1 Introduction

A lack of proper veterinary inspection of animals slaughtered in slaughterhouses may put consumer health at risk; the risk increases further if the consumer does not take appropriate care during meat preparation.

Until approximately 2 decades ago (Filho et al. 1997), about 50% of slaughters carried out in Brazil were clandestine, and occurred without proper sanitary inspection. Clandestine slaughtering prevents sanitary control and reduces the quality of meat that will be acquired by the consumer. The lower price of clandestine meat, the complacency of the population, and a lack of collective awareness were the main elements stimulating this market. Currently, Brazil is one of the largest meat producers worldwide; the quality of meat and standards of sanitary precautions in Brazil have improved and are now both of high standard. There are, however, some aspects that still need to be improved.

Contaminated meat can cause more than 205 diseases, including tuberculosis, cysticercosis, brucellosis, botulism, foot-and-mouth disease, and rabies. The lack of proper sanitary care during slaughter and meat trading threatens the well-being of the population (Raimond 2012).

In humans, taeniasis is a parasitic infection caused by the tapeworm species *Taenia saginata* (beef tapeworm), *Taenia solium* (pork tapeworm), and *Taenia asiatica* (Asian tapeworm). Humans can become infected with these tapeworms by eating raw or undercooked beef (*T. saginata*) or pork (*T. solium* and *T. asiatica*). People with taeniasis may not know they have a tapeworm infection because the symptoms are usually mild or nonexistent (WHO 2017).

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Human taeniasis, caused by *Taenia saginata*, is a consequence of the lack of inspection of slaughtered animals and lack of care in preparing the meat for consumption. When a person feeds on raw or undercooked contaminated beef, cysticerci are trapped in the intestine and develop into adult *Taenia,* which produce many eggs that are eliminated in human feces. These can contaminate soil and water, which will be consumed by bovines, completing the perpetuation cycle of cysticercosis (Barros and Paulino 2006).

During meat inspection, it is possible to confirm the presence of cysticercosis and to take precautions against taeniasis. During inspection, visual examinations, palpation, and cuts of the head, tongue, heart, diaphragm, and intercostal muscles are taken from the slaughtered animal to identify infection. When no cysticerci are found, the meat is approved for consumption; when cysticerci are found, either the affected parts or the whole animal are condemned, depending on the number of cysticerci found (Brasil 1980).

Damage caused by this disease is not limited to domestic consumers and production chain components, it also affects the export market (Carvalho 1997), which is an important market for Brazilian meat. To control taeniasis/cysticercosis, it is essential that the general population, meat handlers, and producers (cattle raisers, slaughterhouse inspectors and workers, consumers) are properly trained and informed, with guidance on personal hygiene, herd health, and the main means of contamination during slaughtering and meat preparation (Funasa 2012).

The lack of information on the occurrence of bovine cysticercosis in the Brazilian state of Mato Grosso do Sul (MS), an important contributor to Brazilian meat, exports, provided motivation for this study. The outcomes of this study are expected to subsidize correctional actions aiming to reduce the occurrence of meat affected by cysticercosis.

The Federal (SIF), State (SIE), or Municipality (SIM) Inspection Services, perform mandatory *post-mortem* inspections of all animals slaughtered in Brazil, and thus provide numerous data, which are recorded on daily slaughter maps, and in weekly, monthly, and annual reports. These are completed by the responsible veterinarian and sent to the Brazilian Ministry of Agriculture (MAPA). These data, when processed statistically and presented comprehensively, provide valuable insight into critical areas where efforts should be concentrated to reduce *Taenia saginata* meat contamination.

The objective of this study was to collect information on the occurrence of cysticercosis in 2 slaughterhouses located at the southern region of MS, Brazil, by consulting records on the origin of slaughtered animals and diseases, prepared after inspection of the *post-mortem* performed by the SIF of the Ministry of Agriculture, Livestock and Supply (MAPA).

2 Materials and methods

The 2 slaughterhouses chosen for this work are located in the southern region of the Brazilian state of MS, Brazil. These slaughterhouses, discretionally named "A" and "B", have about 1800 and 220 employees, and slaughter about 1350 and 500 cattle heads per day, respectively.

In this study, data reported in monthly slaughter maps provided by the SIF of the 2 slaughterhouses registered in this service were used. For slaughterhouse "A", data were collected from January 2011 to December 2012 and referred to the slaughter 279,054 cattle heads. The map contains the following information:

- the number of animals slaughtered monthly,
- the number of male and female animals,
- the number of animals affected by cysticercosis and other diseases, and origin cities of animals.

For slaughterhouse "B", data were collected from January to May 2012, and referred to the slaughter of 23,194 cattle heads. The map contained the same information as A, except for that related to other diseases; only information on cysticercosis were reported, but with additional data on the number of live and calcified cysticerci.

Meat inspection is performed in slaughterhouses and involves cuts in the skeletal muscles and organs where the cysts are found more frequently; diagnosis is made following macroscopic visualization. In the present study, total cysts were calculated, without specifying their location in the animal.

Data were analyzed for normality using the Shapiro–Wilk test; normal data were analyzed based on descriptive statistics and are presented as graphs or tables, depending on the nature of the data. The analyzes were performed in "R", version 2.15 (R Core Team 2015, Vienna). The native *table* function was used to analyze the frequency and percentage of occurrence by month, sub-region of the state, or municipality, and the word cloud package was used for word cloud analysis. The font size used to present municipality names was scaled in relation to the total occurrence of cysticercosis, and was proportionally balanced by the number of cattle head from that location.

A map of the state of MS, Brazil is shown in Fig. 1, and the sub-regions of origin are identified, as used in the present study. Notably, not all sub-regions contain municipalities with herds that are slaughtered by at least one of the slaughterhouses in this study. Thus, sub-regions 4 and 7 were applied to the whole study, and are presented as "zero" when omitted because they do not deliver animals to the slaughterhouses studied.

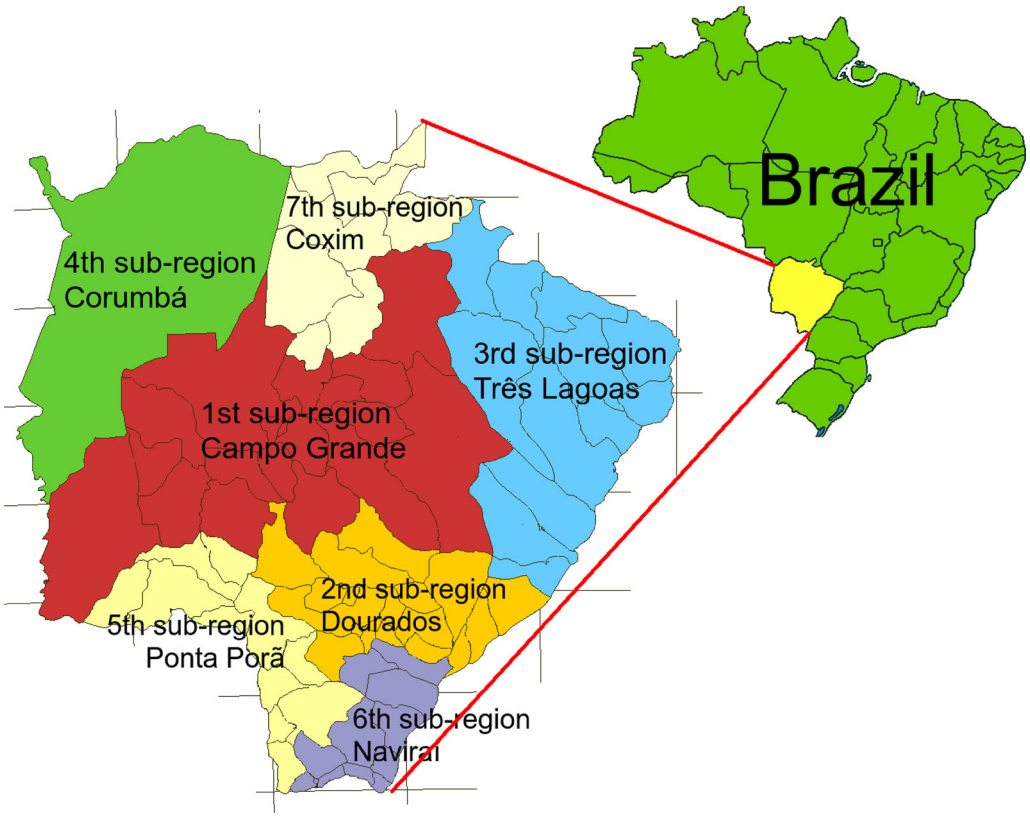

Fig. 1 Map of the Brazilian state of MS, with the respective sub-regions considered into the analysis

3 Results and discussion

3.1 Slaughterhouse "A"

Based on data from slaughterhouse "A", cases of cysticercosis tend to occur more frequently in May, followed by September and October (Fig. 2a). In May, there is usually drought in the state. Costa (2014) noted that research data usually report a larger population of adult worms within the animal body during the dry season, because in this period, parasites are aggravated by the poor nutrition of the animals, due to the low supply of quality pasture. Animals that have access to lower quality pastures are subject to more contamination (Paiva 2008).

Although the frequency of occurrence tends to be higher in the drier months, the highest absolute number of cases was found during the transition from the rainy to the dry season (January–June) (Fig. 2b). Similar data were

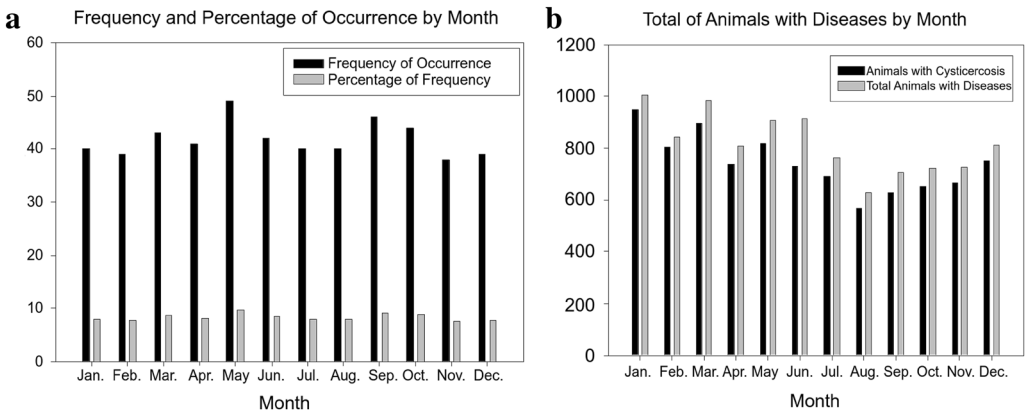

Fig. 2 **a** Frequency of citation of cysticercosis cases, by month of the year, for slaughterhouse "A", located at MS state, Brazil. **b** Number of animals with cysticercosis and with any other type of disease, by month of the year, for slaughterhouse "A", located at MS state, Brazil

reported by Vieira (2005); this is related to the fact that rain increases the resistance of *Taenia* eggs, which have a preference for humid environments. Costa (2014) also reported that in rainy periods, the number of larvae available in the pastures is higher and consequently, in this period, the animals are more susceptible to parasites.

Of note, the frequency indicates how many times a given month has been quoted, and this depends on the number of lots received, but not directly on the number of healthy or diseased animals per lot. The frequency considers whether diseased animals are present in the lot, regardless of the number of diseased animals. In late summer and early fall, at the start of the dry season, farmers usually send more animals to slaughterhouses because of insufficient pasture for the whole lot during the dry season, which probably contributed to a larger percentage of diseased animals reported in May.

Following the same logic between the occurrence frequency (Fig. 3a) and the absolute number of cases (Fig. 3b), cysticercosis occurred more frequently in animals originating from the second sub-region of the MS state (Fig. 3a), followed by sub-regions 5 and 6. Conversely, the largest numbers of animals affected by cysticercosis were from sub-regions 6 and 5 (Fig. 3b). This indicates that these regions of the State deserve special attention from authorities because they frequently send herd lots containing sick animals to slaughterhouses; within each lot, a significant percentage of the animals presented cysticercosis (Fig. 3b).

Considering the data presented in Table 1, the highest reported percentage of municipalities that sent animals lots with cysticercosis was 2.4%, for 17 of the 57 municipalities included in the study. The percentages for each municipality may be due to the presence of rivers that receive untreated urban sewage along their routes, leading to rural properties receiving water contaminated with *Taenia* eggs that will eventually be consumed by animals. The water can carry these eggs over long distances, and this dispersion is highly favored by streams (Vieira 2005).

According to Roppa (2015) the incidence of cysticercosis is increased due to a lack of urban sewage treatment, which pollutes water sources for animals and even for humans. In regions near these municipalities, there are also indigenous communities, rural settlements, or homeless camps, as well as a large flux of temporary workers from other Brazilian regions. In these communities, adapted toilets are common, consisting of holes in the ground surrounded by tarps that are closed superficially when filled with feces and moved. Feces deposited in the open air contribute to the contamination of water and soil. The lack of proper septic containers in rural areas contributes to the pollution of the environment, disseminating pathogens through human feces (Roppa 2015).

Slaughterhouse "A" did not provide data on the total number of animals slaughtered from each municipality of origin (only pooled total data), so it was not possible to calculate the percentage of infected animals by municipality; however, Fernandes (2002) reported that the percentage of animals from MS infected with cysticercosis, slaughtered in a facility located in Andradina-SP, was around 1.46%. The acceptable range for a developing country is around 1–3%; when this range is exceeded, urgent preventive measures are necessary, but this does not always occur (FAO 1986). Some studies (Fernandes and Buzetti 2001) have shown that increased number of cysticercosis cases in cattle is correlated with increased population density.

As shown in Table 1, the municipality with the highest number of cysticercosis cases during the study period was Amambaí, with 930 affected animals. The municipalities with the lowest percentage of lots containing diseased animals (0.2%) were Bandeirantes, Bodoquena, and Miranda. The low index of these municipalities may indicate

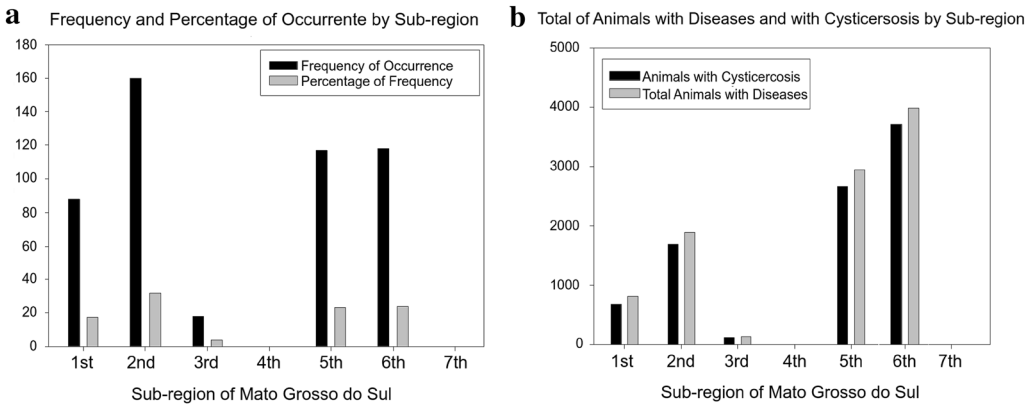

Fig. 3 **a** Frequency of citation of sub-regions of the state of MS, Brazil, regarding the occurrence of cysticercosis. **b** Animals with cysticercosis and with any other diseases, by sub-region of the state of MS, Brazil

Table 1 Number of animals with cysticercosis, total number of diseased animals, frequency of citation of the municipality in case reports and percentage of total citations per year, in the Brazilian state of MS, for slaughterhouse "A"

Municipality	Animals w/Cyst.	Sick Animals	Freq. of Citation	% of Citation	Municipality	Animals w/Cyst.	Sick Animals	Freq. of Citation	% of Citation
Amambaí	930	1019	12	2.4	Ivinhema	95	109	10	2
Anastácio	16	23	10	2	Japora	66	71	12	2.4
Anaurilandia	56	63	8	1.6	Jaraguari	3	4	2	0.4
Angélica	56	68	10	2	Jardim	77	92	10	2
Antonio João	123	134	11	2.2	Jatei	377	418	12	2.4
Aquidauana	4	6	2	0.4	Juti	206	222	12	2.4
Aral Moreira	223	244	11	2.2	Laguna Carapa	188	209	10	2
Bandeirantes	1	5	1	0.2	Maracaju	185	218	12	2.4
Bataguassu	8	8	3	0.6	Miranda	2	3	1	0.2
Bataypora	46	52	10	2	Mundo Novo	69	78	11	2.2
Bela Vista	502	585	12	2.4	Navirai	642	690	12	2.4
Bodoquena	1	1	1	0.2	Nioaque	144	173	12	2.4
Bonito	98	114	9	1.8	N. Alvorada do Sul	51	66	9	1.8
Brasilandia	27	29	4	0.8	Nova Andradina	170	195	10	2
Caarapo	495	516	12	2.4	Novo Horiz. do Sul	41	46	11	2.2
Camapuã	4	4	2	0.4	Paranhos	167	181	9	1.8
Campo Grande	125	138	12	2.4	Ponta Porá	251	271	12	2.4
Caracol	47	54	11	2.2	Porto Murtinho	58	88	11	2.2
Coronel Sapucaia	138	141	8	1.6	Ribas do Rio Pardo	62	76	10	2.0
Deodapolis	27	31	11	2.2	Rio Brilhante	100	118	11	2.2
Dois Irmãos do Buriti	7	7	2	0.4	Sta Rita do Pardo	76	85	9	1.8
Douradina	9	9	5	1.0	Sete Quedas	197	212	12	2.4
Dourados	247	281	12	2.4	Sidrolandia	78	83	10	2.0
Eldorado	340	358	12	2.4	Tacuru	534	557	12	2.4
Gloria de Dourados	28	32	10	2.0	Taquarussu	16	17	7	1.4
Guia L. da Laguna	92	103	11	2.2	Terenos	5	7	2	0.4
Iguatemi	673	751	12	2.4	Tres Lagoas	8	10	2	0.4
Itapora	71	74	9	1.8	Vicentina	7	8	3	0.6
Itaquirai	616	644	12	2.4					

that cattle ranchers of the region are adequately treating their cattle herds, in addition to the existence of adequate sanitary facilities for animal management. Furthermore, municipalities with low numbers of lots sent to slaughterhouse "A" may introduce a significant error into the analysis, which is not considered in Table 1.

Figure 4a shows the frequency of reports for the municipalities with regards to the cases of cysticercosis, and Fig. 4b shows the number of cases of cysticercosis in animals from different municipalities. The size of the font used to present the name of each municipality graphically represents the severity of the disease in that locality. The frequency of occurrence of herds containing diseased animals is very similar between municipalities, but there is a remarkable difference in the total number of diseased animals (comparisons are presented per 100 animals − %).

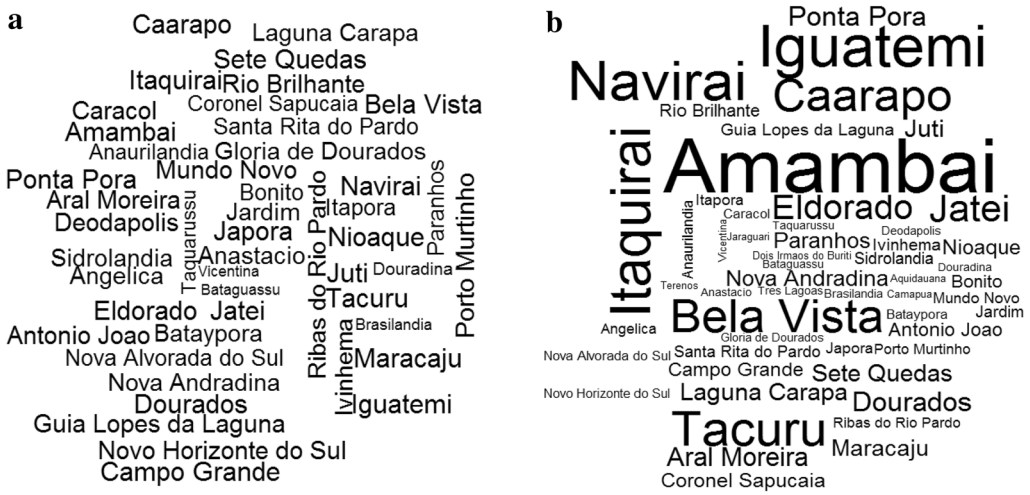

Fig. 4 **a** Word cloud by frequency of citation of municipalities in reports about cysticercosis. The size of the font used represents directly the frequency of citation of that location in the reports of the federal inspection service (SIF), compared to the other municipalities. **b** Word cloud by number of cases of cysticercosis in animals coming from different municipalities. The size of the font used represents directly the frequency of citation of that location in the reports of the federal inspection service (SIF)

3.2 Slaughterhouse "B"

Slaughterhouse "B" only provided a list of cases verified between January and April, thus limiting subsequent analyzes to this period. Cysticercosis appeared more frequently and with the highest occurrence in March, April, and May (Fig. 5a). These data are consistent with most of the information obtained for slaughterhouse "A", in which May was highlighted due to the frequency of citations (Fig. 2a).

In January, although the frequency of lots containing diseased animals was lower, the largest number of animals containing live eggs in their carcass was identified, as well as the largest number of cysticercosis cases. This may be related, at least in part, to the larger size of the lots received at this time (data not available).

In addition, the highest number of calcified cysticerci occurred in April (Fig. 5b), which may indicate that due to the lower occurrence of rainfall (beginning of the dry period in March/April), a higher proportion of cysticerci may have lost viability.

Figure 6a shows that lots from the 6th sub-region presented the highest frequency and percentage cysticercosis. The 5th sub-region presented the highest number of cysticercosis cases, as shown in Fig. 6b.

When analyzing Fig. 6b, one can conclude that the number of calcified cysticerci was greater than the number of live cysticerci. These data are comparable to those obtained by Pianho et al. (2008), who in a study to determine the occurrence of cysticercosis in carcasses and viscera of 8328 cattle slaughtered in a facility located at Campo Mourão-PR, obtained 79 cases of cysticercosis (0.95%), while the number of calcified cysticerci (54 out of

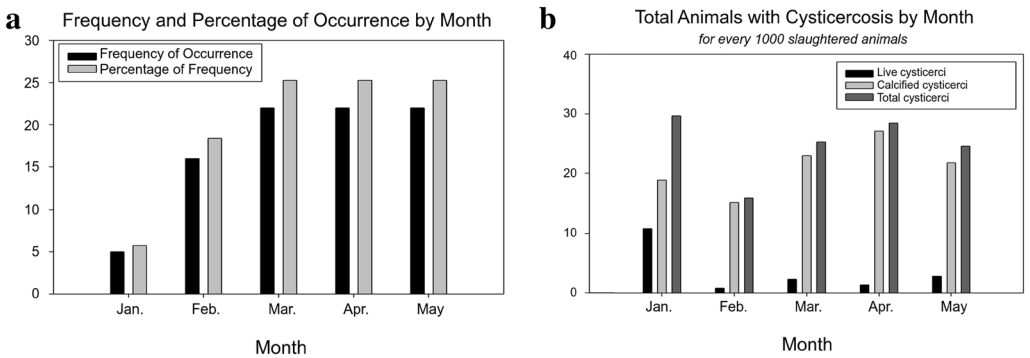

Fig. 5 **a** Frequency of citation of month in the occurrences of cysticercosis, as well as the relative percentage of such frequencies. **b** Animals with cysticercosis (live or calcified) by month, for every 1000 slaughtered animals

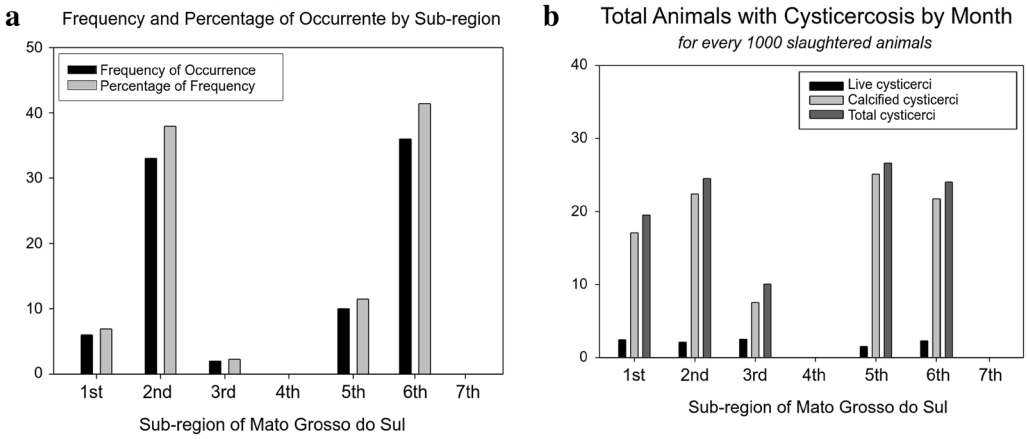

Fig. 6 **a** Frequency of citation of sub-region of the Brazilian state of MS in the reports regarding the occurrence of cysticercosis cases, as well as its relative percentage of frequencies. **b** Animals with cysticercosis eggs (live or calcified) by sub-region of the Brazilian state of MS, for every 1000 slaughtered animals

79) was higher than the number of live cysticerci (12 out of 79). In addition, Pereira et al. (2006) reported that among 9656 animals with cysticercosis, approximately, 1% presented live cysticercosis, and 99% presented calcified eggs.

The high percentage of calcified cysticerci may be due either to the application of vermifuge to cattle, or to the slaughtering of these animals after the death of the cysticerci, which can happen from 18 months to 2 years after contamination. In the first scenario, the animals are being

Table 2 Total slaughtered animals, and occurrence of cysticercosis (live or calcified) for groups of 1000 animals, frequency of citation of the municipality in the case reports and percentage of citations per year, at the state of MS, Brazil

Municipality	Slaug. Anim.	Live Cyst.	Calcif. Cyst.	Freq. of Cit.	% of Cit.	Municipality	Slaug. Anim.	Live Cyst.	Calcif. Cyst.	Freq. of Cit.	% of Cit.
Amambaí	1249	1.60	21.62	4	4.82	Ivinhema	216	0.00	18.52	2	2.41
Anaurilandia	1199	1.67	28.36	4	4.82	Japorã	406	0.00	66.50	4	4.82
Angélica	180	0.00	5.56	1	1.20	Jateí	632	1.58	18.99	5	6.02
Bataiporã	400	0.00	25.00	4	4.82	Juti	3436	1.75	7.86	4	4.82
Bela Vista	126	0.00	15.87	1	1.20	Naviraí	2271	2.20	12.33	3	3.61
Brasilandia	358	0.00	8.38	1	1.20	N. Alv. do Sul	261	0.00	26.82	3	3.61
Caarapó	1653	3.63	15.73	4	4.82	Nova Andradina	1301	0.77	18.45	4	4.82
Campo Grande	379	0.00	13.19	1	1.20	Paranhos	394	2.54	32.99	3	3.61
Coronel Sapucaia	182	0.00	38.46	2	2.41	Ponta Porã	200	0.00	15.00	1	1.20
Deodapolis	61	0.00	32.79	1	1.20	R. do Rio Pardo	1259	3.18	18.27	5	6.02
Dourados	350	11.43	17.14	2	2.41	St. Rita do Pardo	40	25.00	0.00	1	1.20
Eldorado	634	3.15	28.39	4	4.82	Sete Quedas	1084	1.85	27.68	4	4.82
Gloria de Dourados	78	0.00	64.10	3	3.61	Tacuru	2554	1.17	33.67	1	1.20
Iguatemi	1767	5.09	33.39	5	6.02	Taquarussu	40	0.00	100.00	1	1.20
Itaporã	180	0.00	5.56	1	1.20	Vicentina	20	0.00	100.00	1	1.20
Itaquiraí	289	6.92	20.76	3	3.61						

Fig. 7 **a** Word cloud by frequency of citation of municipalities in reports about cysticercosis. The font size represents directly the frequency of citation of that location in the reports of the federal inspection service (SIF). **b**. Word cloud by number of cases of cysticercosis in animals coming from different municipalities. The font size represents the frequency of citation of that location in the reports of the federal inspection service (SIF)

well managed, while in the latter, the herd may be subject to unsuitable management practices.

The municipalities with the highest number of live cysticerci were: Santa Rita do Pardo, Dourados, Itaquiraí, and Iguatemi. The results shown in Fig. 6b also allow the percentage of diseased animals per sub-region of the State to be inferred. While the third sub-region presented between 0.8 and 1.1% of animals contaminated with live or calcified cysticercus, the 5th sub-region presented 2.58 and 2.7% of animals with live or calcified cysticercus, respectively.

Barra and Ferreira (1983) reported cysticercosis in 3.90% of the animals slaughtered in São Paulo in 1983, whose origin was the state of MS; Carmo (1997) observed 1.40% of cysticercosis cases in animals from the region of Dourados-MS in 1997, while Paiva (2006) reported a prevalence of 0.67% of cysticercosis in cattle from 77 municipalities of MS in 2004. There was a notable reduction in the number of cysticercosis cases in animals raised in the Brazilian state of MS from 1983 to 2004; however, from 2004 to 2017, the number of cases seemed to be stable or slightly increased. This indicates the application of Best Management Practices, both in the farm as well as in the slaughterhouses, to guarantee the quality of Brazilian cattle meat.

In Table 2, data from slaughterhouse "B" are presented by municipality; Dourados and Santa Rita do Rio Pardo are highlighted, with 1.14 and 2.50% of animals presenting live cysticerci, respectively. However, the percentage of contaminated animals increases greatly if animals with calcified cysticerci are considered (Table 2).

A comparison of the proportion of animals slaughtered from each municipality of origin is presented in Fig. 7a. Figure 7b illustrates the number of animals with cysticercosis per municipality. In both figures, the font size used is proportional to the number of cases.

4 Conclusions

The percentage of cattle contaminated with cysticercosis in the State of MS is highly dependent on the region of animal origin, varying from 0.8 to 2.5% of infected animals. The municipalities of Dourados and Santa Rita do Rio Pardo are highlighted for the higher proportion of cases, with 1.14 and 2.50%, respectively, of the animals showing live cysticerci.

In regions and/or municipalities with a greater occurrence of live or calcified *Taenia saginata* cysticerci, work related to Best Management Practices for the disease should be carried out with cattle producers, meat inspection workers, and consumers, in order to minimize losses and risks.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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